Genotypic Variation in Climbing Ability Traits in a Common Bean RIL Population

O. Checa[1,2], M.W. Blair[1], S. E. Beebe[1]

[1]Bean Project, CIAT (Centro Internacional de Agricultura Tropical) and [2]Universidad Nacional - Palmira

Introduction:

Climbing beans are vines that can be grown in either monoculture using wooden or bamboo trellises or in intercropping with other support crops such as maize, but in either case an important characteristic of climbing beans is their vegetative vigor and climbing ability. A range of climbing bean architecture exists; some are extremely vigorous producing more biomass at the top of the plant (type IVb), while others distribute biomass more uniformly across their the length of their vines (type IVa). Different types are selected by farmers in given situations, depending on climate, cropping system, harvesting method and growing period. Few studies have analyzed the inheritance of climbing ability in common bean or analyzed the interaction of this trait with soil fertility levels. Information about climbing ability and its component traits could be used by plant breeders to develop climbing bean ideotypes for different production systems. Therefore one of our research objectives has been to develop methods to analyze climbing bean growth and apply these to genetic mapping populations. In this research we analyzed a population of recombinant inbred lines derived from the cross of a climbing bean, G2333, by a bush bean, G19839, grown under high and low phosphorus treatments, for traits involved with climbing ability.

Materials and Methods:

In this experiment we used a set of 84 $F_{5:8}$ recombinant inbred lines (RILs) from the cross G2333 x G19839, where G2333 is a climbing bean from Mexico with type IVa growth habit, while G19839 is a landrace from Peru with type IIIa growth habit. The RILs were grown in four experiments: 1) high phosphorus (HP) – Darien 2002A (2 reps); 2) low phosphorus (LP) – Darien 2002A (2 reps); 3) high temperature - Palmira 2002 B (2 reps); and 4) high phosphorus, cool temperatures - Popayán 2003A (3 reps). Plots consisted of single 3m rows planted with a total of 30 seeds. The distance between seeds was 10 cm and between rows was 1.2 m. The parental genotypes, G2333 and G19839, were planted every 10 rows throughout the experiment to use as visual checks. The cropping systems consisted in a bamboo and wire trellis, with strings tied to individual plants within the plot. The trellis had a height of 2 m. The following variables were evaluated for two plants each within a plot and averaged to produce plot values: plant height (PH), internode length (IL) and number of vines (NV). The latter two traits were evaluated at mid plant height. Climbing ability (CA) was evaluated on a 1 to 9 scale (where 1=highly aggressive climber and 9 = no climbing ability). The scale for climbing ability is an expanded scale compared to the scale for growth habit, which goes from I to IV. Climbing ability and plant height were measured both at flowering and again in pod filling stages. Data were analyzed by non-orthogonal contrasts to compare parents and by analysis of variance (ANOVA) in which sources of variation were: environment, genotype and genotype x environment. Randomized complete block designs were used for all four experiments.

Results and Discussion:

In the comparison of the parents, G2333 had significantly taller plant height and longer internode length than G19839 in all four environments (Table 1). The number of vines was also larger in G2333 than in G19839 in all environments, but difference were only significant in Palmira and in Popayán. Similarly, climbing ability (as measured on an inverse scale) was greater in G2333 than in G19839. Meanwhile, in the comparison of the recombinant inbred lines (RILs), the majority of traits showed significant differences, except for 1) climbing ability in the low phosphorus treatment in Darien and 2) number of vines in Palmira and in the high phosphorus treatment in Darien. In general, for both parents and RIL comparisons, the most favorable environment was Popayán, followed by the high phosphorus treatment in Darien, the low phosphorus treatment in Darien and Palmira. Broad sense heritabilities ranged from 0.12 to 0.86 and were higher in the more favorable environments than in the less favorable environments. It was also notable, that the phenotypic trait values of the RILs were wider than those for the parents indicating that transgressive segregation may be acting on climbing ability and its component traits.

Table 1. Phenotypic difference between parents and among RILs, and broad sense heritability (BSH^2) for climbing ability (CA), internode length (IL), number of vines (NV) and plant height (PH) in a recombinant inbred line (RIL) population derived from the cross G2333 x G19839 evaluated at flowering (1) and pod filling (2) growth stages in four environments.

Environment	Trait	Parents			RILs			BSH^2
		G2333	G19839	F_c	MIN	MAX	F_c	
HP- Dairen	PH1	1.97	0.85	8.70^{**}	0.28	2.39	2.46^{***}	0.71
	PH2	2.54	1.28	9.25^{**}	0.73	3.15	2.85^{***}	0.66
	IL2	18.53	7.00	19.41^{***}	3.50	26.50	5.07^{***}	0.81
	CA1	2.95	6.75	19.39^{***}	1.00	7.00	4.47^{***}	0.74
	CA2	2.95	5.60	10.11^{**}	1.00	6.00	3.78^{***}	0.79
	NV2	1.79	1.57	0.16^{ns}	0.50	4.00	1.14^{ns}	0.12
LP- Dairen	PH1	1.37	0.50	8.01^{**}	0.28	1.97	1.77^{**}	0.46
	PH2	1.78	0.96	2.91^{**}	0.50	3.00	1.68^{**}	0.42
	IL2	13.80	5.90	9.16^{**}	4.50	21.50	2.91^{***}	0.67
	CA1	4.00	6.45	4.22^{*}	1.00	7.00	1.39^{ns}	0.31
	CA2	3.90	6.25	4.00^{**}	1.00	7.00	1.36^{ns}	0.29
	NV2	1.23	1.01	0.32^{ns}	0.42	3.25	1.70^{**}	0.41
Palmira	PH2	1.65	0.71	10.52^{*}	0.28	2.20	2.40^{***}	0.61
	IL2	12.80	7.50	4.5^{ns}	4.50	19.95	1.45^{*}	0.34
	CA1	4.65	7.50	12.39^{***}	3.00	9.00	1.90^{**}	0.52
	CA2	4.50	6.95	3.93^{ns}	2.00	9.00	1.61^{*}	0.41
	NV2	2.67	1.42	14.04^{***}	0.38	2.25	1.24^{ns}	0.47
Popayán	PH1	2.29	0.86	37.88^{***}	0.18	2.75	4.54^{***}	0.80
	PH2	2.77	1.70	14.83^{***}	0.17	3.50	4.11^{***}	0.77
	IL2	19.49	12.04	9.89^{**}	5.00	26.50	2.93^{***}	0.67
	CA1	3.35	7.25	58.47^{***}	3.00	8.00	6.68^{***}	0.86
	CA2	2.25	4.95	21.77^{***}	1.00	9.00	5.22^{***}	0.82
	NV2	4.22	3.08	4.48^{**}	0.33	5.75	2.60^{***}	0.66

Acknowledgements: This work was supported by a Fontagro / BID grant to MB. We are grateful to Y. Viera and A. Hincapie for excellent field assistance.